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(54) **Lubricant additive for use with alcohol fuels**

(57) A lubricant additive for use with alcohol fuels is provided comprising a major amount of a polyalkylene glycol of an alkene having 2 to 3 carbons, and minor amounts of an aromatic primary amine, an aromatic secondary amine and a phosphoric acid ester. A preferred composition comprises 93-98.5 wt % of a polypropylene glycol, 0.5-2.0 wt % of an aromatic primary amine, 0.5-2.0 wt % of an aromatic secondary amine, and 0.5-2.0 wt % of a phosphoric acid ester. The preferred compounds are polypropylene glycol 2000, ortho-phenylenediamine, N-phenyl-2-naphthylamine, and ortho-tricrecylphosphate.

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SPECIFICATION

Lubricant additive for use with alcohol fuels

The present invention is directed to an additive formulation for use with conventional automotive lubricants to produce a lubricant suitable for internal combustion engines burning alcohol fuels, such as methanol or ethanol.

Commonly used automotive lubricants are not effective in alcohol burning engines as evidenced by excessive engine wear and progressively increasing rates of lubricant consumption. One reason for this is the large difference in chemical reactivity of the combustion products from gasoline and alcohol automotive fuel systems. In an alcohol fuel system, a number of lubricant degradation reactions occur which are not encountered in the gasoline fuel system. These chemical reactions cause the increased corrosiveness of alcohol fuels. For instance, methanol readily oxidizes to form formaldehyde and formic acid. This reaction is represented by Equation 1.

$$\underset{\text{(methanol)}}{CH_3OH} \rightarrow \underset{\text{(formaldehyde)}}{HCHO} \rightarrow \underset{\text{(formic acid)}}{HCOOH} \qquad (1)$$

Most vehicles using methanol fuel suffer from excessive upper-cylinder corrosion and bearing wear resulting from the formic acid produced by methanol combustion. Formic acid reacts with the conventional automotive lubricant's organic amine additives which function as antioxidants, corrosion inhibitors, and anti-wear agents. The amine additives neutralize the formic acid. However, the conventional additives seem unable to adequately neutralize the amount of formic acid formed in methanol combustion. These reactions are represented in Equations 2 and 3.

$$\underset{\text{(primary amine)}}{RNH_2} + \underset{\text{(formic acid)}}{2HCOOH} \xrightarrow{\text{neutralization}} RNH_2\cdot 2HCOOH \qquad (2)$$

$$\underset{\text{(secondary amine)}}{R_2NH} + \underset{\text{(formic acid)}}{HCOOH} \xrightarrow{\text{neutralization}} R_2NH\cdot HCOOH \qquad (3)$$

Formaldehyde is highly reactive with phenolic and glycol additives. Formaldehyde reacts with the phenols which are used as antioxidants and with the polymers containing hydroxyl groups which are used as ashless dispersants. These reactions take place under acidic conditions and increase as the organic amine additives are depleted by reaction with formic acid. These formaldehyde reactions, represented by Equation (4), contribute significantly to oil degradation in a methanol fuel system.

$$\underset{\text{(phenol or glycol}}{ROH} + \underset{\text{(formaldehyde)}}{HCHO} \xrightarrow[\text{aldol condensation}]{\text{acid catalyzed}} ROCH_2OR \qquad (4)$$

There is a need for a lubricant additive which minimizes the oxidation of methanol to formaldehyde and formic acid and minimizes excessive formaldehyde and formic acid reactions in order to prolong the life of lubricant additives which are deplected rapidly by reaction with formaldehyde and formic acid. Similarly, there is a need for a lubricant additive which minimizes the oxidation of ethanol to acetaldehyde and acetic acid and minimizes excessive reactions of those components.

Another significant problem in an alcohol fuel system is that zinc dialkyldithiophosphate, a major multifunctional additive in most conventional lubricants, readily transesterifies and thereby loses many of its anti-wear properties. The transesterification reaction involves the interchange of an alcohol alkyl group, such as methanol or ethanol, with an existing ester, such as zinc dialkyldithiophosphate, to form a new ester. A transesterification reaction is represented in Equation 5.

$$\underset{\text{(existing ester)}}{RCOOR'} + \underset{\text{(methanol)}}{CH_3OH} \xrightarrow{\text{acid catalyzed}} \underset{\text{(new ester)}}{RCOOCH_3 + R'OH} \qquad (5)$$

The transesterification reaction is acid catalyzed and therefore occurs after the amine base additives in the lubricant are depleted by reaction with aldehydes and acids formed in the combustion process.

Transesterification is not a major mechanism of oil degradation in hydrocarbon fuel systems but is a primary mechanism of oil degradation in methanol and other alcohol fuel systems. For instance, when methanol and ethanol are blended with gasoline, the magnitude of the trasesterification reaction is proportional to the amount of alcohol in the mixture.

Another cause of increased corrosiveness in an alcohol burning engine is the increased solubility of carbon dioxide in the alcohol. For instance, carbon dioxide is much more soluble in methanol than in water. Both water and methanol are usually present in the cooler parts of the crank case as products of combustion. The water reacts with the fuel combustion products, such as SO_3, NO_2, and CO_2 to form the corresponding acids, sulfuric acid, nitric acid, and carbonic acid, as represented in Equations 6, 7 and 8.

$$SO_3 + H_2O \rightarrow \underset{\text{(sulfuric acid)}}{H_2SO_4} \quad (6)$$

$$NO_2 + H_2O \rightarrow \underset{\text{(nitric acid)}}{HNO_3} \quad (7)$$

$$CO_2 + H_2O \rightarrow \underset{\text{(carbonic acid)}}{H_2CO_3} \quad (8)$$

These acids reacting with metals in the engine are one of the major causes of corrosion in an internal combustion engine. The lubricants commonly used in a hydrocarbon fuel system effectively neutralize these acids with basic additives such as organic amines and alkaline metal compounds. However, carbonic acid levels are significantly higher in a methanol or other alcohol fuel system than in a gasoline fuel system due to the increased solubility of CO_2 in alcohols. The same may be true of nitric acid formed from NO_2 combustion products. Absorption of carbon dioxide appears to be an important reason for the unexpectedly high corrosiveness of alcohol fuels.

Lubricant analysis indicates that corrosion inhibitors composed of sulfonates, naphthenates or other alkaline metals are extensively depleted by reaction with carbonic acid, resulting in the precipitation of insoluble carbonates of the alkaline metals. The precipitation reaction is represented in Equations 9 and 10.

$$RSO_3Ba + H_2CO_3 \rightarrow BaCO_3 + RCOOH \quad (9)$$

$$RSO_3Ca + H_2CO_3 \rightarrow CaCO_3 + RSO_3H \quad (10)$$

This precipitation reaction competes with the neutralization of carbonic acid by organic amines. Although the neutralization is faster and more likely to occur, the reaction with alkaline metal salts increases as the organic amines are depleted. Thus, there is a need for a lubricant additive wherein depletion of the organic amine additives due to neutralization of formic acid or acetic acid and carbonic acid occurs less rapidly, thus decreasing the likelihood that alkaline metal salts will be depleted by the precipitation reactions represented in Equations 9 and 10.

The present invention sets out to provide a lubricant additive for use in an alcohol fuel burning internal combustion engine which provides protection against corrosive and engine wear effects caused by alcohol.

The present invention provides a lubricant additive which can be added to conventional automotive lubricants to produce a lubricant suitable for use in a methanol or ethanol burning engine, comprising a major amount of a polyalkylene glycol of an alkene having 2 to 3 carbons, and minor amounts of an aromatic primary amine, an aromatic secondary amine, and a phosphoric acid ester. Preferred amounts of the compounds contained in the lubricant additive of the present invention are about 93-98.5 wt.% of a polyalkylene glycol, about 0.5-2.0 wt.% of an aromatic primary amine, about 0.5-2.0 wt.% of an aromatic secondary amine, and about 0.5-2.0 wt.% of a phosphoric acid ester.

There is also provided a lubricant composition comprising an additive of the invention. The additive *per se* may be combined with the lubricant to obtain the resultant composition or the individual ingredients thereof, alone or in combination, may be mixed with the lubricant to produce the desired composition and the present invention includes the compositions however prepared. It is preferred that the additive itself be used.

The invention further includes a method of preparing a lubricant composition comprising mixing together a lubricant (e.g. an oil comprising a conventional automotive lubricant) and, as an additive, a polyalkylene glycol of an alkene having 2 to 3 carbons, an aromatic primary amine, an aromatic secondary amine and a phosphoric acid ester, the polyalkylene glycol being a major amount of the additive in the resultant composition and each of the other additive ingredients being a minor amount of the additive in the lubricant composition. Of course, the order in which the lubricant and each additive ingredient are mixed together is not of significance. Thus, the additive ingredients may be combined with the lubricant in combination and/or singly.

The lubricant additive of the present invention comprises a polyalkylene glycol of an alkene having 2 to 3 carbons, such as polypropylene glycol, polyisopropylene glycol, or polyethylene glycol; an aromatic primary amine, such as ortho-, meta-, or para- phenylenediamine, ortho-, meta-, or para- toluidine, aniline,

naphthylamine, benzylamine, tolulenediamine, or naphthalenediamine; an aromatic secondary amine, such as N-phenyl-2-napthylamine, phenyl-α-naphthylamine, phenyl-β-naphthylamine, tolylnaphthylamine, diphenylamine, ditolylamine, phenyltolylamine, 4 4'-diaminodiphenylamine, or N-methylaniline; and a phosphoric acid ester, such as orthol, meta-, or para- tricresylphosphate, dibutylphenylphosphate, tributylphosphate, tri2-ethylhexylphosphate, trioctylphosphate, diphenyl ortho phosphonate, dicresyl ortho phosphonate, trilauryl ortho phosphonate, tristearyl ortho phosphonate.

A preferred polyalkylene glycol is polypropylene glycol and a preferred polypropylene glycol is polypropylene glycol 2000. A preferred aromatic primary amine is ortho-phenylenediamine; a preferred aromatic secondary amine is N-phenyl-2-naphthylamine, and a preferred phosphoric acid ester is ortho-tricrecylphosphate.

Preferably, the lubricant additive of the present invention contains about 93 to 98.5 wt. % of a polyalkylene glycol of an alkene having 2 to 3 carbons, about 0.5 to 2.0 wt. % of an aromatic primary amine, about 0.5 to 2.0 wt. % of an aromatic secondary amine, and about 0.5 to 2.0 wt. % of a phosphoric acid ester.

A preferred composition of the present invention comprises about 93 to 98.5 wt. % polypropylene glycol 2000, about 0.5 to 2.0 wt. % of ortho-phenylene-diamine, about 0.5 to 2.0 wt. % of N-phenyl-2-naphthylamine, and about 0.5 to 2.0 wt. % of ortho-tricecylphosphate.

All of the above compounds are commercially available. The lubricant additive of the present invention is made by blending together each of the above compounds. The lubricant additive of the present invention can be used by adding approximately one pint of the lubricant additive to a 5 quart oil change. The lubricant additive of the present invention will provide effective protection against corrosive and engine wear effects caused by methanol or ethanol for oil change intervals of more than 4000 miles and in some cases up to 6000 miles.

The polyalkylene glycol, preferably polypropylene glycol, functions as a methanol or ethanol solubilizer, a non-ash dispersant and a scavenger for aldehydes. A solubilizer of this type is required to dissolve the large amounts of methanol or ethanol introduced into the lubricant prior to combustion. The polyalkylene glycol solubilizes the methanol or ethanol thereby preventing dry spots on the upper cylinder and bearing surfaces. In the absebce of glycol, methanol or ethanol is insoluble in hydrocarbon lubricants and dry spots can occur. In addition, a polyalkylene glycol contains hydroxyl groups which react with the aldehydes formed by the oxidation of methanol or ethanol. The reaction product of a polyalkylene glycol and formaldehyde or acetaldehyde is also a good solvent for methanol or ethanol and continues to function as a methanol or ethanol solubilizer.

The aromatic primary amine, preferably ortho-phenylenediamine, functions primarily as a base number additive to neutralize formic or acetic and carbonic acids formed by the oxidation of methanol or ethanol and by the reaction of water and carbon dioxide, respectively.

The aromatic secondary amine, preferably N-phenyl-2-naphthylamine, also serves to neutralize formic or acetic and carbonic acids however, its primary function is as an antioxidant. It minimizes the oxidation of methanol or ethanol to their respective aldehydes and acids.

The presence of larger amounts (about 0.5 to 2.0 wt. %) of organic amines in the present invention, as compared to the amount generally contained in conventional lubricant additives (about 0.25 wt. %), minimizes depletion of alkaline metal salts, such as naphthenates and sulfonates. The alkaline metals are depleted when they react with carbonic acid to form insoluble carbonates, competing with the neutralization of carbonic acid. The neutralization reaction is faster and more likely to occur, but the precipitation reaction becomes a problem when the organic amines become depleted. With more organic amines present, more carbonic acid is neutralized and there is less carbonic acid available to react with the alkaline metals.

The phosphoric acid ester, preferably ortho-tricrecylphosphate, functions as an anti-wear agent and when used with methanol or ethanol fuel it is superior to the conventional anti-wear agent, zinc dialkyldithiophosphate. Zinc dialkyldithiophosphate is almost universally used in automotive lubricants for gasoline burning engines but loses its anti-wear properties rapidly in a methanol or ethanol burning engines because it readily transesterifies with the alcohols.

A lubricant additive can be evaluated based on the amounts of wear elements, such as iron, lead, and copper, detected in an oil sample by spectrochemical analysis after the engine has been driven a certain number of miles after an oil change. These metals or wear elements show up in the lubricant as a result of excessive corrosion of or failure of certain engine components made of that metal as well as normal mechanical wear.

Table 1 sets forth criteria for evaluation of lubricant wear element data. The primary and secondary source in the engine of each wear element is given as well as the average amount in ppm's of each wear element which would be found in the oil at the "break-in" point and at the "post break-in" point. Engine wear levels during the break-in period tend to be relatively high. After the engine has been broken in, the wear levels reach a plateau, remaining stable for about 50,000 miles, depending on the particular vehicle and degree of maintenance. The "break-in" point for an average engine is generally in the 0 to 10,000 mile range. The evaluation criteria found in Table 1 will be used to evaluate the data set forth in Examples 1 through 5.

In examples 1 and 3, data is also included regarding the percent volume of diluted fuel, the percent volume of total solids, the percent volume of water, viscosity, and base number of the oil sample tested.

The average amount of oil dilution caused by blow-by is about 3% for both alcohol and gasoline fuels. The amount of dilution is significantly greater during cold weather because of increased condensation. A sticking

choke, improper ignition, low operating temperatures and blow-by are the factors most commonly contributing to fuel dilution. Dilution in excess of 3% decreases the viscosity of oil, causing increased engine wear.

Solids in engine oil usually consist of soot, metal salts, road dirt, sludge, and oxidized oil caused by undesirable engine operating conditions such as poor ignition, inefficient air filters, and blow-by. These solids can cause engine malfunction if they prevent oil from getting to critical engine and bearing surfaces. A total solids value greater than 3% indicates a serious problem.

Water contents in excess of ·1% are generally considered excessive in vehicles using gasoline fuels. Because of the hygroscopic properties of alcohols, vehicles using this fuel often have water contents that exceed 0.5%. High water contents accelerate both organic sludge formation and corrosion reactions. High values can result from atmospheric water mixing with the alcohols, leaks from the cooling system, lower operating temperatures of an inoperative pollution control valve system.

An automotive lubricant with normal viscosity has the same numerical value as the Society of Automotive Engineers (SAE) grade of the oil being used. High viscosity values generally indicate oil degradation caused by infrequent oil changes. Low viscosity values are generally caused by fuel dilution. Viscosity values are not directly proportional to engine wear, a change of 10 units in either direction can indicate significant lubricant degradation.

Base number is a measure of the oil detergent action and its ability to inhibit corrosion. New automotive oils commonly have a base number of 4 to 5. For any oil, a reading of 1 or less indicates a dangerous depletion of additive reserves. A base number of 2 is generally considered to provide an adequate margin of protection in a gasoline burning engine.

TABLE 1

Criteria for Evaluation of Lubricant Wear Element Data

Evaluation Criteria, ppm					*Source*	
Break-In		*Post Break-in*				
Wear Element	*Average*	*Excessive*	*Average*	*Excessive*	*Primary*	*Secondary*
Iron (Fe)	200-400	400	10-100	200	cylinder wall	block, crank-shaft, wrist pins, rings, valves, oil pump, fuel tank
Molybdenum (Mo)	2-4	5	0-2	3	cylinder wall	block, crank-shaft, wrist pins rings, valves, oil pump, fuel tank
Lead (Pb)	100-300	300	5-100	150	bearings	flashing, TEL in fuel
Copper (Cu)	50-150	150	5-75	100	bearings	bushings, wrist pins, cam, valve train, thrust washers, oil pump

TABLE 1 (Continued)

Criteria for Evaluation of Lubricant Wear Element Data

Evaluation Criteria, ppm					*Source*	
Break-In		*Post Break-in*				
Wear Element	*Average*	*Excessive*	*Average*	*Excessive*	*Primary*	*Secondary*
Tin (Sn)	20-50	50	1-10	15	bearings	flashing
Chromium (Cr)	2-10	10	1-5	5	rings	crankshaft, exhaust valves
Nickel (Ni)	3-5	5	1-2	4	valves, crankshaft	rings
Aluminum (Al)	30-100	100	1-15	30	pistons, aluminum blocks	

Example 1

An oil sample comprising a conventional automotive lubricant and 10 wt. % of the lubricant additive of the present invention comprising about 97 to 98.5 wt. % polypropylene glycol 2000, about 0.5 to 1.0 wt. % of ortho-phenylenediamine, about 0.5 to 1.0 wt. % of N-phenyl-2-naphthylamine, and about 0.5 to 1.0 wt. % of ortho-tricrecylphosphate was taken from the crank case in methanol fueled engine A which had been driven the equivalent of 12,459 miles with an oil change approximately 2,000 miles prior thereto. The sample contained less than 0.5% volume of diluted fuel, 1.5% volume total solids, less than 0.05% volume water, and had a total base number of 3.70. The oil had an initial viscosity of SAE 30 and the viscosity remained unchanged during testing.

The base number of 3.70 was well above the adequate base number of 2, indicating that the aromatic primary and secondary amines had not been depleted and were still available for neutralizing formic acid and carbonic acid and preventing oxidation of methanol to formaldehyde and formic acid.

The percent volume of diluted fuel and percent volume total solids were well below the average 3% value indicating no increase in engine wear. The percent volume water was well below the 0.1% value which is considered to be excessive and thus indicates no corrosion problems due to water content. The viscosity of the oil sample was normal.

Spectrochemical analysis revealed that the following amounts of wear elements were present in the oil sample: 36 ppm iron; 66 ppm lead; 107 ppm copper; 2 ppm chromium; 4 ppm aluminum; 2 ppm nickel; and 12 ppm tin. The engine had been driven the equivalent of 12,459 miles which is just over "break-in" mileage of about 10,000 miles. Thus, the sample will be evaluated using both "break-in" and "post break-in" criteria. It should be noted, however, that the mileage is closer to "break-in" mileage and thus the "break-in" criteria are a more accurate measure of the amount of engine wear.

Referring to Table 1, the iron, lead, tin, nickel and aluminum content in the sample was less than the average content of these wear elements at "break-in" mileage. The copper content was within the average range at "break-in" mileage. The chromium content was at the low end of the average range at "break-in" mileage. At "post break-in" mileage, the lead, chromium, nickel, and aluminum contents were within the average range. The iron content was at the lower end of the average range.

The data provided by Example 1 illustrates that the lubricant additive of the present invention is effective in a methanol burning engine at or near break-in mileage.

Example 2

An oil sample comprising the conventional automotive lubricant and 10 wt. % of the lubricant additive used in Example 1 was taken from the crank case of methanol fueled engine A which had been driven the equivalent of 14,034 miles with an oil change at approximately 3,575 miles prior thereto. It has a total base number of 3.08. The base number of 3.08 was well above the adequate base number of 2, indicating that the aromatic primary and secondary amines have not been depleted and are still available for neutralizing the acids and preventing oxidation of methanol.

Spectrochemical analysis revealed that the following amount of wear elements were present in the oil sample: 52 ppm iron; 64 ppm lead; 102 ppm copper; 1 ppm chromium; 5 ppm aluminum; 1 ppm nickel; and 10 ppm tin. Since the engine had been driven an equivalent 14,034 miles, the post break-in evaluation criteria shown in Table 1 were applied.

Referring to Table 1, the iron, lead, chromium, aluminum, nickel, and tin content in the sample were all within the average range at post break-in mileage.

The data in Examples 1 and 2, including the base numbers, indicate that the lubricant additive of the

present invention will be effective at 4,000 mile oil change intervals, and should be effective at longer oil change intervals of up to 6,000 miles. The small wear element levels in Examples 1 and 2 also indicate that engine A was in good condition.

Example 3

An oil sample comprising a conventional automotive lubricant and 10 wt. % of the lubricant additive used in Example 1 was taken from the crank case of methanol fueled engine B which had been driven the equivalent of 31,724 miles with an oil change at approximately 2,000 miles prior thereto. The oil sample contained less than 0.5% volume diluted fuel, about 5.0% volume total solids, less than 0.05% volume water, and had a total base number of 2.38. The oil had an initial viscosity of SAE 30 which remained unchanged during testing.

The base number was greater than the adequate base number of 2 indicating that there were substantial amounts of primary and secondary aromatic amines available for neutralizing acids and preventing oxidation of methanol.

The percent volume diluted fuel and percent volume total solids were far below the average 3% value and thus indicated no increase in engine wear. The percent volume water was also far below the 0.1% value considered excessive and thus also indicates no serious corrosion problem due to the presence of water. The total solids value was greater than the average value of 3% indicating the presence of more than an average amounts of solids. The viscosity of the oil sample was normal.

The spectrochemical data shows that the following wear elements were present in these amounts: 47 ppm iron; 44 ppm lead; 83 ppm copper; 17 ppm chromium; 4 ppm aluminum; 2 ppm nickel; and 14 ppm tin. The wear element content of iron, lead, aluminum, and nickel was within the average range in Table 1 for post break-in mileage. Thus, Example 3 also illustrates that the lubricant additive of the present invention is effective in a methanol burning engine at "post break-in" mileage.

Example 4

An oil sample comprising a conventional automotive lubricant and the 10 wt. % of lubricant additive used in Example 1 was taken from the crank case of methanol fueled engine B which had been driven the equivalent of 33,307 miles with an oil change at approximately 3,583 miles prior thereto. The oil sample had a total base number of 2.46. The base number is greater than the adequate base number of 2 and thus, indicates that there are substantial amounts of primary and secondary aromatic amines available for neutralizing acids and preventing oxidation of methanol.

Spectrochemical data shows that the following wear elements were present in these amounts: 85 ppm iron; 63 ppm lead; 76 ppm copper; 16 ppm chromium; 3 ppm aluminum; 1 ppm nickel; and 11 ppm tin. The wear element content of iron, lead, aluminum and nickel was within the average range shown in Table 1 for post break-in mileage. The copper content was 1 ppm higher than the average amount but much less than 100 ppm which is considered to be excessive. Thus, Example 4 illustrates that the lubricant additive of the present invention is effective in a methanol burning engine at post break-in mileage, and that it will be effective at 4,000 mile oil change intervals.

Example 5

An oil sample comprising a conventional automotive lubricant and 10 wt. % of the lubricant additive used in Example 1 was taken from the crank case of methanol fueled engine B which has been driven the equivalent of 34,815 miles with an oil change at approximately 5,091 miles prior thereto. The oil sample had a total base number of 1.68. Although the base number is slightly less than the base number of 2, it still indicates that there are adequate amounts of primary and secondary aromatic amines available for neutralizing acid and preventing oxidation of methanol.

Spectrochemical data shows that the following wear elements were present in these amounts: 77 ppm iron; 160 ppm lead; 67 ppm copper; 10 ppm chromium; 0 ppm aluminum; 1 ppm nickel; and 0 ppm tin. The wear element content of iron, copper and nickel were within the average range at post break-in mileage as shown in Table 1. Less than the average amounts of aluminum and tin were found in the sample. Thus, Example 5 illustrates that the lubricant additive of the present invention is effective in a methanol burning engine at post break-in mileage at 5,000 mile oil change intervals.

Engine B of Examples 3, 4 and 5 was in poor condition at the beginning of testing as evidenced by the high chromium levels 2,000 miles after the oil change. The wear element content levels and the base numbers in Examples 3, 4 and 5 did not change significantly during the testing period indicating that the lubricant additive of the present invention is effective even in engines in poor condition.

Example 6

Oil samples were taken from a methanol burning automotive engine prior to running the engine and 20 hours after continuous running of the engine in three test runs. In the first test run, the oil in the engine contained no lubricant additive. In the second and third test runs, the oil in the engine contained 10 wt. % of the lubricant additive of the present invention. The following wear element data was obtained by spectrochemical analysis.

Test Run	Test Hour	PPM of Wear Element						
		Fe	Pb	Cu	Cr	Al	Ni	Sn
1	0	4	10	115	1	2	2	7
	20	125	13	120	4	8	3	11
2	0	3	10	115	1	2	1	3
	20	14	10	94	1	2	1	5
3	0	3	10	115	2	2	1	6
	20	21	10	110	3	2	1	6

Comparing Test Run 1 to Test Runs 2 and 3, the wear element content indicates that without the lubricant additive of the present invention, a methanol burning engine experiences a significant increase in engine wear. The increase is especially evident from the content of iron. In Test Run 1, after 20 hours of continuous running, 125 ppm of iron was present, whereas in Test Runs 2 and 3 after 20 hours of continuous running only 14 and 21 ppm of iron, respectively, was present.

In Test Run 1 in general the amount of all wear elements increased after 20 hours of engine running; whereas in Test Run 2 the lead, chromium, aluminum and nickel content remained the same, while the copper content decreased and the tin content increased by only 2 ppm. In Test Run 3, the lead, aluminum, nickel and tin content remained the same, while the copper content decreased and the chromium content increased by 1 ppm. Thus, it can be concluded that a methanol burning engine using the lubricant additive of the present invention will experience much less engine wear than without the lubricant additive of the present invention.

CLAIMS

1. A lubricant additive for use with alcohol fuels, comprising a major amount of a polyalkylene glycol of an alkene having 2 to 3 carbons, and minor amounts of an aromatic primary amine, an aromatic secondary amine and a phosphoric acid ester.
2. A lubricant additive as claimed in claim 1 comprising about 93.0 to 98.5 wt % of the polyalkylene glycol, about 0.5 to 2.0 wt % of the aromatic primary amine, about 0.5 to 2.0 wt % of the aromatic secondary amine, and about 0.5 to 2.0 wt % of the phosphoric acid ester.
3. A lubricant additive as claimed in claim 2 wherein said polypropylene glycol content is about 97.0 to 98.5 wt. %, said aromatic primary amine content is about 0.5 to 1.0 wt. %, said aromatic secondary amine content is about 0.5 to 1.0 wt. % and said phosphoric acid ester content is about 0.5 to 1.0 wt. %.
4. A lubricant additive as claimed in any of the preceding claims wherein the polyalkylene glycol is polypropylene glycol.
5. A lubricant additive as claimed in claim 4 wherein the polypropylene glycol is polypropylene glycol 2000.
6. A lubricant additive as claimed in any one of the preceding claims wherein the aromatic primary amine is ortho-phenylenediamine.
7. A lubricant additive as claimed in any one of the preceding claims wherein the secondary aromatic amine is N-phenyl-2-naphthylamine.
8. A lubricant additive as claimed in any one of the preceding claims wherein the phosphoric acid ester is ortho-tricrecylphosphate.
9. A lubricant additive for use with alcohol fuels, comprising about 97-98.5 wt % of polypropylene glycol 2000, about 0.5-1.0 wt % ortho-phenylenediamine, about 0.5-1.0 wt % of N-phenyl-2-naphthylamine, and about 0.5-1.0 wt % of ortho-tricrecylphosphate.
10. A lubricant additive substantially as hereinbefore described in Example 1.
11. A lubricant composition comprising a lubricant additive as claimed in any one of the preceding claims.
12. A method of preparing a lubricant composition comprising mixing together a lubricant and, as an additive, a polyalkylene glycol of an alkene having 2 to 3 carbons, an aromatic primary amine, an aromatic secondary amine and a phosphoric acid ester, the polyalkylene glycol being a major amount of the additive in the lubricant composition and the aromatic primary amine, aromatic secondary amine and phosphoric acid ester each being a minor amount of the additive in the lubricant composition.
13. A method as claimed in claim 12 wherein the additive is as defined in any one of claims 2 to 9.

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